CHAPTER 2

WATER QUALITY ASSESSMENT OF LAKES

WATER QUALITY ASSESSMENT OF LAKES

Section 314 of the Clean Water Act of 1987 requires that states submit a lake water quality assessment as part of their biennial 305(b) report. Six areas are to be included in the assessment. These are:

(1) An identification and classification according to eutrophic condition, of all publicly-owned lakes in a state.

(2) A general description of the state's procedures, processes, and methods (including land use requirements) for controlling lake pollution.

(3) A general discussion of the state's plans to restore the quality of degraded lakes.

(4) Methods and procedures to mitigate the harmful effects of high acidity and remove or control toxics mobilized by high acidity.

(5) A list and description of publicly-owned lakes for which uses are known to be impaired, including those lakes that do not meet water quality standards or that require implementation of control programs to maintain compliance with applicable standards, and those lakes in which water quality has deteriorated as a result of high acidity that may reasonably be due to acid deposition.

(6) An assessment of the status and trends of water quality in lakes including the nature and extent of pollution loading from point and nonpoint sources and the extent of impairment from these sources, particularly with regard to toxic pollution.

The U.S. Environmental Protection Agency (EPA) has developed a guidance document Guidelines for the Preparation of the 1992 State Water Quality Assessments (305(b) Reports (August 1991), which includes a section on lake assessment reports. Kentucky's report generally complies with the guidelines suggested by the EPA.

Lake Identification

Appendix B lists publicly-owned lakes for which data were available to assess trophic status. Much of this information came from recent lake surveys (1989-1991) conducted by the Division of Water and Murray State University as part of a cooperative agreement funded under Section 314 of the Clean Water Act. The surveys were conducted on lakes which had originally been sampled by the Division of Water in 1981-1983 and on 11 lakes which had not previously been surveyed. Not all of the significant publicly-owned lakes in Kentucky are included in the table because data have not been collected from all such lakes. For purposes of this report, publicly-owned lakes are those lakes that are owned or managed by a public entity such as a city, county, state, or federal agency where the public has free access for use. A nominal fee for boat launching charged by concessionaires may occur on some of these lakes. Lakes that are publicly-owned, but restrict public access because they are used solely as a source of domestic water supply, are not included. These lakes do not qualify for federal restoration funds under the Clean Lakes Program and were not monitored in the lake classification survey. In addition, Lewisburg Lake has been removed from the list of significant lakes because public access has been restricted. EPA guidance suggests that all significant lakes be included in state surveys. The term "significant" is to be defined by the state so that all lakes that have substantial public interest and use would be included. For this purpose, Kentucky considers all of the publicly-owned lakes it has surveyed and listed in Appendix B and also those which have not yet been surveyed, but qualify as publicly-owned lakes, as significant. All of these lakes have substantial local or regional public interest and use.

Trophic Status

Lake trophic state was assessed by using the Carlson Trophic State Index (TSI) for chlorophyll α. This method is convenient because it allows lakes to be ranked numerically according to increasing eutrophy and also provides for a distinction (according to TSI value) between oligotrophic, mesotrophic and eutrophic lakes. The growing season average TSI (chlorophyll α) value was used to rank each lake. Growing season was defined as the April through October period. A distinction was made for those lakes which exhibited trophic gradients. If lakes exhibited trophic gradients or embayment differences, those areas were often analyzed separately.

While there are several other methods of evaluating lake trophic state, the accuracy and precision of the chlorophyll α analytical procedure (determined from Division of Water quality control data) and proven ability of the chlorophyll α TSI to detect changes, made it the index of choice for classifying lakes in Kentucky's program.

Chlorophyll α concentration data from the ambient monitoring program, and the most current chlorophyll α data collected during the spring through fall seasons (a minimum of 3 samples) by the U.S. Army Corps of Engineers (COE) on several reservoirs which they manage, were used to update the trophic classifications for this report. Other data were obtained from a report on a study of Lake Barkley conducted by Dr. Joe M. King of Murray State University. Data averaged from water column depths of up to 20 feet were used in calculating TSI values. Table 15 contains the trophic state rankings of lakes of 5,000 acres or more in size and Table 16 lists and ranks the trophic state of lakes less than 5,000 acres in size. Lakes that have updated classifications are in bold face type. A "+" or "-" symbol is used to indicate a trend of increasing or decreasing trophy. Trends were defined as a change of ten units from a previous TSI score. This represents a doubling or halving of Secchi disk depth and was chosen because it is a noticeable indication of change.

A summary of Tables 15 and 16 indicates that of the 102 classified lakes, 61 (60%) were eutrophic (3 being hypereutrophic), 30 (29%) were mesotrophic, and 11 (11%) were oligotrophic. This is based on the status of the major areas of lakes and does not account for the trophic gradient that exists in some reservoirs nor the trophic status of the embayments of others. The dynamic nature of these reservoirs makes it more difficult to assign them a single trophic state because their water residence times, the nature of major inflows, and their morphology can result in different trophic states in separate areas. The tables indicate that trophic gradients exist in Barren River and Laurel River lakes and that certain embayments of Lake Cumberland are eutrophic, while the main lake area is oligotrophic.

The 102 assessed lakes have a total area of 214,962 acres. Only those portions of lakes Barkley, Kentucky, and Dale Hollow lying within Kentucky were included in the total. Tennessee reports on those portions within its borders. Of the total, 51 percent (109,005 acres) were eutrophic while 29 percent (63,513 acres) were oligotrophic and 20 percent (43,444 acres) were mesotrophic. The decrease in eutrophic acres from the 1990 305(b) report is largely because Green River and Nolin River lakes were reclassified as mesotrophic based on more current lake data.

Lake Pollution Control Procedures

Kentucky utilizes several approaches to control pollution in its publicly owned lakes. The approach chosen is dependent upon the pollutant source and the characteristics of each lake. Point sources of potential pollution are more controllable than nonpoint sources. The following procedures are routinely used to control point sources of pollution.

Permitting Program

A lake discharge guidance procedure is in effect and is applied to any new construction permit for a facility that proposes to discharge into a lake, or for any application for a lake discharge permit under the Kentucky Pollutant Discharge Elimination System (KPDES). An applicant is required to evaluate all other feasible means of routing the discharge or to explore alternate treatment methods that would result in no discharge to a lake. As a last resort, a lake discharge may be permitted. Permits for domestic wastes require secondary treatment and a discharge into the hypolimnion in the main body of the lake. More stringent treatment may be required depending upon lake characteristics. Surface discharges are not allowed. A permit may also be denied to a prospective discharger if the discharge point is within five miles of a domestic water supply intake.

Table 15
Trophic State Rankings for Lakes
5,000 Acres or Greater in Area
(by Carlson TSI (Chl α) Values)

Lake	TSI (Chl α)*	Acres
	Eutrophic	
Barkley	61	45,600
Kentucky	**54**	**48,100**
	Mesotrophic	
Barren River	50	7,205
Beaver Creek Arm	57 (Eutrophic)	1,565
Skaggs Creek Arm	50	1,230
Green River	**48**	**8,210**
Rough River	48	5,100
Cave Run	45	8,270
Nolin	**43**	**5,790**
	Oligotrophic	
Cumberland	38	49,364
Lily Creek Embayment	**61 (Eutrophic)**	**144**
Beaver Creek Embayment	**57 (Eutrophic)**	**742**
Laurel River	34	4,990
Midlake-Laurel River Arm	47 (Mesotrophic)	754
Headwaters-Laurel River Arm	58 (Eutrophic)	316
Dale Hollow	33	4,300

*Scale: 0-40 Oligotrophic (nutrient poor, low algal biomass)
41-50 Mesotrophic (slightly nutrient rich, moderate amount of algal biomass)
51-69 Eutrophic (nutrient rich, high algal biomass)
70-100 Hypereutrophic (very high nutrient concentrations and algal biomass)

Bold Type = Updated Classifications,

Table 16
Trophic State Rankings for Lakes
Less Than 5,000 Acres in Area
(by Carlson TSI (Chl α) Values)

Lake	TSI (Chl α)*	Acres
	Hypereutrophic	
Beaver Dam	**86**	**50**
Mitchell	**85**	**58**
Happy Hollow	**75**	**20**
	Eutrophic	
Swan	69	193
Arrowhead	68	37
Fish	68	27
Spurlington	68+	36
Campbellsville City	67+	63
Jericho	**67+**	**137**
Marion County	67	21
McNeely	**67**	**51**
Reformatory	**67**	**54**
Taylorsville	**67**	**3,050**
Guist Creek	65	317
Wilgreen	**65**	**169**
Shelby (Shelby County)	**64+**	**17**
Buck	64	19
Metcalfe County	**64+**	**22**
Willisburg	64	126
Briggs	**63**	**18**
Kingfisher	**63**	**30**
Metropolis	63	36
Flat	62	38
Greenbriar**	**62**	**66**
Carpenter	**61**	**64**
Doe Run	61+	51
Sympson	**61+**	**184**
Burnt Pond	60	10
Long Pond	60	56
Moffit	**60**	**49**

Table 16 (Continued)

Lake	TSI (Chl α)*	Acres
Shelby (Ballard County)	**60**	**24**
Turner	60	61
Carnico	**59**	**114**
Scenic	**59**	**18**
A.J. Jolly	58	204
Energy	58	370
Corinth	57	96
Freeman	**57**	**160**
Sand Lick	57	74
Beaver	56	158
Bullock Pen	56	134
Elmer Davis	56	149
Kincaid	**56**	**183**
Malone	**56**	**826**
Mauzy	**56**	**84**
Spa	**56**	**240**
Washburn	**56**	**26**
Boltz	55	92
General Butler	55	29
George	**55**	**53**
Fishpond	**54**	**32**
Herrington	54	2,940
Salem	**54**	**99**
Shanty Hollow**	**54**	**135**
Carr Fork	53	710
Pennyrile	**53**	**47**
Williamstown**	**53**	**300**
Caneyville	**52**	**75**
Bert Combs	**51**	**36**
	Mesotrophic	
Chenoa	**50**	**37**
Corbin	**50**	**139**
Dewey	**50+**	**1,100**
Liberty	50	79
Long Run	50	27

Table 16 (Continued)

Lake	TSI (Chl α)*	Acres
Morris	**50**	**170**
Beshear	**49**	**760**
Hematite	49	90
Honker	49-	190
Laurel Creek	**49**	**42**
Linville	**49**	**273**
Pan Bowl	**49**	**98**
PeeWee	49	360
Greenbo	48	181
Luzerne	**48**	**55**
Mill Creek (Monroe County)	**48**	**109**
Smokey Valley	47	36
Tyner	**46**	**87**
Wood Creek	46	672
Blythe	**45**	**89**
Campton	**45**	**26**
Mill Creek (Powell County)	**43**	**41**
Paintsville	**43**	**1,139**
Providence City	**42**	**35**
Grapevine	**41-**	**50**
	Oligotrophic	
Grayson	39	1,512
Buckhorn	**38**	**1,230**
Loch Mary	**38**	**135**
Fishtrap	37	1,143
Martins Fork	37	334
Stanford	36	43
Cannon Creek**	**33**	**243**
Cranks Creek	**32**	**219**

*Scale: 0-40 Oligotrophic 51-69 Eutrophic
41-50 Mesotrophic 70-100 Hypereutrophic
Bold Type = Updated Classifications, ** = 2 samples only,
+/- = upward (more eutrophic) or downward (less eutrophic) trend

Water Quality Standards Regulations

Kentucky has not adopted specific criteria to protect lake uses. Warmwater aquatic habitat, domestic water supply (if the lake is used for this purpose), and primary and secondary contact recreation criteria are generally applicable to lakes. In specific cases, a provision in the water quality standards regulation can be utilized to designate a waterbody as nutrient limited if eutrophication is a problem. Point source dischargers to the lake and its tributaries can then have nutrient limits included in their permits.

Lakes that support trout are further protected by another provision that requires dissolved oxygen in waters below the epilimnion to be kept consistent with natural water quality.

Kentucky is not planning to adopt statewide criteria specifically for lakes. A site-specific approach to lake pollution control is more realistic and feasible.

Specific Lake Legislation and Local Initiatives

The Kentucky General Assembly has the prerogative to pass legislation to protect lakes. This action has been taken for Taylorsville Lake. House Joint Resolution No. 4 prohibits issuing any discharge permits that allow effluents to be directly discharged into the lake. It also prohibits issuing any permits that allow inadequately treated effluents to be discharged into contributing tributaries that drain the immediate watershed of the lake. In addition, wastewater permit applications in the basin above the lake must be evaluated to ensure that discharges will not adversely affect the lake or its uses. Other provisions provide for stringent on-site wastewater treatment requirements, promotion of nonpoint source controls, and proper management of sanitary landfills in the watershed.

Lake protection associations are not formally organized in Kentucky. This is one mechanism that has proven to be successful in preventing lake pollution in other states. Local ordinances can be passed that restrict land use activities and on-site treatment systems and lead to pollution abatement. Local grass roots opposition to activities which may degrade lakes can lead to state agency action. An example is the petition process in the state's surface mining regulations which can lead to lands being declared unsuitable for mining. Such a petition has been successfully made to protect the water quality of Cannon Creek Lake in Bell County. The lake is used as a water supply for the City of Pineville and is also used for fishing and recreation.

Lake Monitoring

Monitoring water quality in lakes is a part of Kentucky's ambient monitoring program and is described in Chapter 4. The objectives of the monitoring program are flexible so that lakes can be monitored for several purposes. These include:

- detection of trends in trophic state
- impacts of permit decisions
- ambient water quality characterization
- nonpoint source impacts
- long-term acid precipitation impacts
- pollution incidences such as fish kills and nuisance algal blooms
- new initiatives such as fish tissue analysis for toxics and fecal coliform surveys in swimming areas.

Lake Restoration Plan

Kentucky has not developed a formal state Clean Lakes Program. Several states have adopted a program modeled after the federal Clean Lakes Program and have had state funds appropriated to aid in lake restoration projects. The impetus for developing these programs has been the historical importance of lakes as recreational and aesthetic resources in these states. Pollution or the potential for pollution has prompted support for state development of these programs. Pollution of lakes in Kentucky has not reached a point where there is a recognized need to develop a state program of this nature.

The Division of Water does participate in the federal Clean Lakes Program. The Natural Resources and Environmental Protection Cabinet is the state agency designated by the Governor to receive federal assistance under this program. Kentucky has received three assistance awards. Two helped to fund projects which classified lakes in the state according to trophic state and assessed their need for restoration. The other award helped to fund a diagnostic/feasibility study of McNeely Lake in Jefferson County.

The Division of Water cooperated with local and federal agencies in all of these projects and prepared a grant for implementation of the restoration plan for McNeely Lake. The grant was not awarded because it was technically not eligible for assistance under federal guidelines. However, Jefferson County passed a bond issue to finance the implementation of the plan. It was completed in December of 1988. The Division is monitoring the lake as part of its ambient program to document water quality improvements.

The Division of Water is ready to cooperate with local agencies and other interested groups to participate in the federal Clean Lakes Program. The preparation of the lake assessment chapter in the 305(b) report is a requirement for future participation in that program.

Toxic Substance Control/Acid Mitigation Activities

Kentucky does not have publicly-owned lakes that have high acidity caused by acid precipitation; consequently, this requirement does not apply and will not be addressed.

Identification of Impaired and Threatened Lakes

Table 17 summarizes information on overall use support for Kentucky lakes. This information was gathered from published annual reports produced by the COE on reservoirs which they manage, from research reports by other investigators, and from Division of Water data bases. The total acres assessed are equal to the acres monitored. The analysis is based on chemical data relating to iron, manganese, and dissolved oxygen problems, biological data relating to algal biomass (blooms), algae causing taste and odor problems, macrophyte infestations, and fish kill reports. Criteria were also developed based on other indicators of lake use support (see Table 18). One of the criteria for support of aquatic life indicates that a use was not being fully supported if the average dissolved oxygen concentration within the epilimnion was less than 5 mg/l. This criterion and pH are related to aquatic life standards.

Table 17
Summary of Lake Use Support

Degree of Use Support	Assessment Basis (Monitored)	Total Assessed
Acres Fully Supporting	100,454	100,454
Acres Threatened	94,839	94,839
Acres Partially Supporting	12,931	12,931
Acres Not Supporting	6,738	6,738

Acres Assessed - 214,962
Total Kentucky Lake Acreage - 228,385

The total acres reported in Table 17 is based on the Division of Water's Dam Inventory Files and the acres inventoried in the lake classification program. The assessed acres represent over 90 percent of the publicly-owned lake acreage in the state. The U.S. EPA published a draft document in December, 1991 entitled Total State Waters: Estimating River Miles and Lake Acreages for the 1992 Water Quality Assessments (305(b) Reports), which lists total lake acreage in Kentucky as 182,169 acres. The acreages are computer derived from USGS 1:24,000 scale maps for lakes shown on the USGS 1:100,000 scale map series. This total is less than the estimate in this report. The Division of Water derived its estimate of lake acreages from engineering drawings in its Dam Inventory Files, from reported acres (at certain elevations) in U.S. Army Corps of Engineers project reports of its major reservoirs in the state, and by planimetering USGS 1:24,000 scale map series for lakes with no reported acres. These are

Table 18
Criteria for Lake Use Support Classification

Category	Warmwater Aquatic Habitat	Secondary Contact Water Recreation	Domestic Water Supply
Not Supporting:	At least two of the following:	At least one of the following:	At least one of the following:
	1. Fish kills caused by poor water quality	1. Widespread excess macrophyte/macroscopic algal growth	1. Chronic taste and odor complaints caused by algae
	2. Severe hypolimnetic oxygen depletion	2. Chronic nuisance algal blooms	2. Chronic treatment problems caused by poor water quality
	3. Dissolved oxygen average less than 5 mg/l in the epilimnion		
Partially Supporting: (At least one of the listed criteria).	1. Dissolved oxygen average less than 5 mg/l in the epilimnion	1. Localized or seasonally excessive macrophyte/macroscopic algal growth	1. Occasional taste and odor complaints caused by algae
	2. Severe hypolimnetic oxygen depletion	2. Occasional nuisance algal blooms	2. Occasional treatment problems caused by poor water quality
	3. Other specific cause (i.e. low pH)	3. High suspended sediment concentrations during the recreation season	
		4. Other specific cause (i.e. low pH).	
Fully Supporting:	1. None of the above	1. None of the above	1. None of the above

considered to be more accurate estimates than those reported by U.S. EPA. Many lakes have been classified by use in Kentucky and are listed in Kentucky's water quality standards. Waters not specifically listed by use in water quality regulations are generally classified for the uses of warmwater aquatic habitat, primary and secondary contact recreation, and domestic water supply at points of withdrawal. Lake use support is based on these uses. Primary contact recreation was not assessed because the primary indicator of use support (fecal coliform bacteria) was not measured as part of agency monitoring programs.

Detailed information on formerly assessed lakes can be found in the report on the lake classification program entitled Trophic State and Restoration Assessments of Kentucky Lakes, which was published in 1984 by the Division of Water. Detailed information on newly assessed lakes will be included in the final report of the lake assessment project. Appendix B lists summary information on all of the lakes assessed.

Table 19 and Table 20 list lakes according to whether their uses are not supported or are partially supported. The tables indicate which criteria from Table 18 were used to determine nonsupport or partial support and the probable causes and sources for the support not being achieved. Table 21 lists those lakes which fully support their uses.

Ninety-one percent of the total acres assessed supported uses while nine percent did not fully support uses. Nine of the ten lakes over 5,000 acres in size fully supported uses. Rough River Lake is the exception. The domestic water supply use of this lake is partially supported because of occasional treatment problems caused by natural sources of manganese. More than half of the small lakes fully supported their designated uses (55 of 92) or 60 percent. Twenty-eight of these lakes (30%) partially supported a particular use. Nine lakes did not support one or more uses. Briggs, Herrington and Mauzy lakes are new additions to this category. Reformatory Lake was removed from the list and placed in the partial support category because of improved water quality. In total, of the 102 lakes assessed, 64 fully supported their uses (63%), 29 lakes partially supported uses (28%) and nine lakes did not support one or more uses (9%).

Hazards to human health through consumption of fish or swimming in waters contaminated by bacteria were not considered as problems in any of the listed lakes. Table 22 summarizes use support information for lakes based on acres and number of lakes.

EPA guidance asks for a list of threatened lakes. These are defined as lakes that fully support uses now, but may not in the future because of anticipated sources or adverse trends of pollution. Table 17 indicates the total acres classified as threatened. Table 23 lists the lakes and indicates what uses are threatened and the causes and sources of the threats.

Table 19
Lakes Not Supporting Uses

Lake	Use Not Supported*	Criteria**	Cause	Source
Briggs	WAH	2,3	Nutrients	Lake fertilization
Corbin	DWS	1	Nutrients	Municipal point sources and Agricultural nonpoint sources
Herrington	WAH	1,3	Nutrients	Municipal point sources and Agricultural nonpoint sources, septic tanks
Jericho	WAH	2,3	Nutrients	Agricultural nonpoint sources
Loch Mary	DWS	2	Metals (Mn) and other inorganics (noncarbonate hardness)	Surface mining (abandoned lands)
Mauzy	WAH	2,3	Nutrients	Lake fertilization
McNeely	WAH	2,3	Nutrients	In-place contaminants (sediments)
Sympson	DWS	1	Nutrients	Agricultural nonpoint sources
Taylorsville	WAH	2,3	Nutrients	Municipal point sources and Agricultural nonpoint sources

*WAH - Warmwater Aquatic Habitat, SCR - Secondary Contact Recreation,
DWS - Domestic Water Supply
**Refer to Table 18

Table 20
Lakes Partially Supporting Uses

Lake	Use*	Criteria**	Cause	Source
Beshear	WAH	1	Nutrients	Natural
Buckhorn	SCR	3	Suspended solids	Surface mining
Campbellsville	WAH	1	Nutrients	Agricultural nonpoint sources
Caneyville	DWS	1	Nutrients	Natural
	SCR	1	Nutrients	Natural
Carpenter	SCR	1	Shallow lake basin	Natural
	WAH	1	Nutrients	In-place contaminants (sediments)
Carr Fork	SCR	3	Suspended solids	Surface mining
Cranks Creek	WAH	3	pH	Mining (abandoned lands)
	SCR	3	pH	Mining (abandoned lands)
Dewey	SCR	3	Suspended solids	Surface mining
Fishtrap	SCR	3	Suspended solids	Surface mining
George	WAH	1	Nutrients	Agricultural nonpoint sources
Guist Creek	DWS	1	Nutrients	Agricultural nonpoint sources
	WAH	1	Nutrients	
Honker	WAH	1	Nutrients	Natural
Kincaid	WAH	1	Nutrients	Unknown
Laurel Creek	DWS	1	Nutrients	Natural
Laurel River (Headwaters)	SCR	1	Nutrients	Municipal point sources and Agricultural nonpoint sources
Liberty	DWS	2	Metals (Fe and Mn)	Natural
Martins Fork	SCR	3	Suspended Solids	Surface mining
Marion County	SCR	2	Nutrients	Lake fertilization
Metcalfe County	SCR	1	Shallow lake basin	Natural
	WAH	2	Nutrients	Agricultural nonpoint sources

Table 20 (Continued)

Lake	Use*	Criteria**	Cause	Source
Morris	DWS	1	Nutrients	Agricultural nonpoint sources
Reformatory	WAH	2	Nutrients	Agricultural nonpoint sources
Rough River	DWS	2	Metals (Mn)	Natural
Salem	SCR	1	Shallow lake basin	Natural
Sand Lick Creek	WAH	1	Nutrients	Agricultural nonpoint sources
Scenic	WAH	1	Nutrients	In-place contaminants (sediments)
Shelby (Shelby Co.)	WAH	1	Nutrients	Agricultural nonpoint sources/In-place contaminants (sediments)
Spa	WAH	1	Nutrients	Agricultural nonpoint sources
Stanford	DWS	1	Nutrients	Natural
Wilgreen	WAH SCR	2 2	Nutrients Nutrients	Septic tanks Septic tanks
Washburn	WAH	2	Nutrients	Unknown

*WAH - Warmwater aquatic habitat, SCR - Secondary contact recreation,
DWS - Domestic water supply
**Refer to Table 18

Table 21
Lakes Fully Supporting Uses

Size		
5000 Acres or Larger	**Less than 5000 Acres**	
Barkley	A.J. Jolly	Linville
Barren	Arrowhead	Long Pond
Cave Run	Beaver	Long Run
Cumberland	Beaver Dam	Luzerne
Dale Hollow	Bert Combs	Malone
Green	Blythe	Metropolis
Kentucky	Boltz	Mill Creek (Monroe Co.)
Laurel River (except for headwaters)	Buck	Mill Creek (Powell Co.)
Nolin	Bullock Pen	Mitchell
	Burnt Pond	Moffit
	Campton	Paintsville
	Cannon Creek	Pan Bowl
	Carnico	Peewee
	Chenoa	Pennyrile
	Corinth	Providence City
	Doe Run	Shanty Hollow
	Elmer Davis	Shelby (Ballard Co.)
	Energy	Smokey Valley
	Fish	Spurlington
	Fish Pond	Swan Pond
	Flat	Turner
	Freeman	Tyner
	General Butler	Williamstown
	Grapevine	Willisburg
	Grayson	Wood Creek
	Greenbo	
	Greenbriar	
	Happy Hollow	
	Hematite	
	Kingfisher	

Table 22
Use Support Summary for Lakes

(by Acres)

Use	Supporting	Supporting But Threatened	Partially Supporting	Not Supporting
Fish Consumption	214,962	0	0	0
Aquatic Life	156,974	49,239	2,469	6,280
Swimming	214,743	0	219	0
Secondary Contact	116,203	93,700	5,059	0
Drinking Water*	80,623*	0	5,826	458

Total Assessed Acres = 214,962
*Total Assessed Acres for Domestic Water Supply = 86,449

(by Number)

Use	Supporting	Supporting But Threatened	Partially Supporting	Not Supporting
Fish Consumption	102	0	0	0
Aquatic Life	78	2	16	6
Swimming	101	0	1	0
Secondary Contact	87	2	13	0
Drinking Water*	30	0	7	3

Total Assessed Lakes = 102
*Total Assessed for Domestic Water Supply = 40

Table 23
Threatened Lakes

Lake	Use* Threatened	Cause	Source
Kentucky	SCR	Macrophyte infestations	Natural or introduced exotic species
	WAH	Low dissolved oxygen	Unspecified nonpoint sources
Paintsville	WAH	Salinity/brine	Petroleum activities
Barkley	SCR	Suspended solids	Unspecified nonpoint sources

*SCR - Secondary Contact Recreation, WAH - Warmwater Aquatic Habitat

Table 24 indicates the causes responsible for nonsupport of lake uses. As noted in previous 305(b) reports, nutrients cause the greatest percentage of nonsupport and affect the largest number of lakes. Nutrients can stimulate a proliferation of algae, which may cause taste and odor problems in lakes used for domestic water supplies. Dissolved oxygen can also be lowered in surface waters by very productive algal populations that stimulate microbial respiration and may result in fish kills or a decrease in oxygen to levels that are not conducive to the support of healthy populations of fish. Metals are the second largest contributor to nonsupport of uses. The nonsupport is attributable to iron and manganese effects on lakes used for domestic water supplies. These metals are solubilized from lake sediments under anoxic conditions and cause water treatment problems. Suspended solids (the next largest contributor to nonsupport of uses) cause several reservoirs in eastern Kentucky to not fully support secondary contact recreational uses. Priority pollutants (toxics) did not cause any of the lake use impairments.

Table 25 indicates the sources responsible for nonsupport of lake uses. Agricultural sources are the single source responsible for the highest percentage of use nonsupport (29%). Nonpoint sources including agriculture account for the highest percentage of lake uses not being supported (57%). More detailed studies in watersheds of the lakes in the agriculture category are necessary before contributing sources of nonpoint pollution can be distinguished. Surface mining for coal (resource extraction) is the next greatest nonpoint source contributor to lake uses not being fully supported. Lake recreational uses are impaired because waters become turbid after receiving runoff water, laden with sediment from lands disturbed by surface mining activities. This reduces the incentive for secondary contact uses. Municipal point sources were responsible for 21 percent of the use nonsupport, as were natural causes.

Table 24
Causes of Use Nonsupport* In Lakes

Major Impact**	Number of Lakes Affected	Acres	% Contribution (by Acres)
Nutrients	29	9,520	48
Metals (Fe/Mn)	3	5,314	27
Suspended solids	5	4,517	23
pH	1	219	1
Other (Shallow lake basin)	3	185	1
Other inorganics (noncarbonate hardness)	1	135	<1

*Nonsupport is a collective term for lakes either not supporting or partially supporting uses
**No moderate or minor impacts were noted

Table 25
Sources of Use Nonsupport* in Lakes

Source	Major Impact (Acres)	Moderate/Minor Impact (Acres)
Point Sources		
Municipal	6,445	455
Nonpoint Sources		
Agriculture	8,727	
Resource Extraction	4,871	
Septic tanks	3,109	
Other		
Natural	6,474	
Lake fertilization	123	
In-place contaminants	334	
Unknown	209	

*Nonsupport is a collective term for lakes either not supporting or partially supporting uses

Water Quality Trend Assessment

Trophic Trends

One of the objectives of the ambient monitoring program is to assess eutrophication of Kentucky lakes. The monitoring strategy is to obtain at least two years of data during the growing season on each lake. After the data is assessed, a decision is made either to continue monitoring or to assess another lake.

A review of current lake data from the ambient monitoring program, data retrieved through STORET on COE managed lakes, data from the lake assessment program, and other reports resulted in an assessment of trophic trends at several lakes. As mentioned earlier, a change in the chlorophyll TSI value (averaged over the April - October growing season) of 10 units was used to indicate a trophic change. A discussion of trends from the above databases follows.

Lakes in the Assessment Program. TSI values were compared for those lakes assessed in 1981-1983 that had been resurveyed in 1989, 1990, and 1991. Comparisons of two data sets does not provide a strong trend analysis because the intervening years were not sampled. They do, however, indicate a change. The comparisons, as noted in Table 16 show that Spurlington, Campbellsville City, Jericho, Shelby (Shelby County), Metcalfe County, and Doe Run lakes were more eutrophic. Lake Jericho's change resulted in its warmwater aquatic habitat use not being supported. Wood Creek Lake changed from an oligotrophic to a mesotrophic state. No uses were impaired. Sympson Lake changed from a mesotrophic to a eutrophic state. Honker and Grapevine lakes changed from eutrophic to mesotrophic states.

Lakes in the Ambient Monitoring Program. The following is a discussion on individual lakes which have been monitored over several years by the Division of Water, the COE, and other researchers. Analyses are based on the combined databases. Trophic trends are indicated by a change in TSI values of 10 units or greater. The extent of these databases gives the trend assessments a high level of confidence.

Green River Lake. COE data from 1981 indicated that this lake might be changing from a mesotrophic to a eutrophic state. Subsequent sampling in 1985 and 1986 by the DOW showed the main body of the lake to be mesotrophic. The 1989 COE data indicated that the lake was eutrophic. The TSI value changed from 44 (mesotrophic) to 55 (eutrophic). Monitoring by the COE will indicate if this eutrophic trend continues. The Division monitored the lake in 1990 and 1991. The data showed that the lake was less eutrophic in 1990 and that it had returned to a mesotrophic state in 1991.

Nolin River Lake. The 1988 305(b) report indicated that this lake was changing from a mesotrophic to a eutrophic state. The period of record showed the lake to be mesotrophic from 1975 through 1983 (TSI average was 44). Data from 1982 through

1987 showed a eutrophic trend. The TSI value was 55 in 1987. The DOW monitored the lake in 1988 and verified that the lake was eutrophic (TSI was 52). COE data from 1990 showed the lake was mesotrophic (TSI was 43). The lake appears to have stabilized at a low eutrophic/high mesotrophic state. Its changes in trophic state are probably related to annual variations in nutrient loading which are driven by meteorological conditions.

Reformatory Lake. The Division of Water classified this lake as hypereutrophic in the 1984 305(b) report. Its aquatic life use was not supported because of severe hypolimnetic oxygen depletion and dissolved oxygen of less than 5 mg/l in the epilimnion. Subsequent investigations indicated that livestock operations in the watershed were the major source of nutrients which caused the degraded lake conditions.

Best management practices were implemented to reduce nutrient loading to the lake from these livestock operations with the help of the University of Kentucky Agricultural Extension Service. Monitoring of the lake in 1985 and 1986 showed that these practices brought about water quality improvements. Algal biomass had decreased, water clarity improved, and dissolved oxygen remained above 5 mg/l in the epilimnion, and there was less severe oxygen depletion in the hypolimnion. Total phosphorus, the nutrient of concern, had decreased.

Subsequent monitoring from 1987 through 1990 showed that there was a reversal in water quality. The lake was hypereutrophic in 1989 and again did not support aquatic life use. Site visits in the watershed in 1990 revealed that the best management practices had not been maintained and that nutrients from current livestock operations increased the phosphorus loading to the lake.

Livestock operations ceased in late 1990 due to economic factors. Monitoring in 1991 indicated an improvement in water quality. Dissolved oxygen in the epilimnion did not go below 5.0 mg/l. The lake was less eutrophic. Hypolimnetic oxygen depletion was still severe with dissolved oxygen less than 1 mg/l. The lake was moved from the not supporting category to partially supporting in this report because of the improved water quality. The Division is continuing to monitor the lake to document water quality conditions.

McNeely Lake. The Division is monitoring this lake to document changes in water quality as a result of the diversion of effluent from package treatment plants in the watershed to a pipeline that discharges at a location below the lake's dam. Three years of monitoring after this diversion (which began in December of 1988) have shown some improvement in water quality. The lake is no longer hypereutrophic as it was in 1987 and 1988. TSI values for 1989, 1990, and 1991 were 65, 64, and 66 respectively, which places it in the eutrophic category. Spring total phosphorus values in surface waters were 79 percent less after diversion. The average spring epilimnetic concentration dropped from 420 ug/l to 87 ug/l. This is still enough phosphorus to support eutrophic conditions. The lake experienced dissolved oxygen concentrations of less than 5 mg/l in the epilimnion and had severe hypolimnetic oxygen depletion in 1991. These factors caused the lake to be categorized as not supporting aquatic life. The Division is continuing to monitor the lake to determine the nature of water quality improvements. Evidence from studies on sediment cores indicate that the lake was eutrophic before development occurred in the watershed. Some lower level of eutrophy may be all that can be expected of a lake of this nature.

Lake Jericho. Lake Jericho is a 137 acre lake in Henry County formed by a dam on the Little Kentucky River. It was first monitored by the Division in 1983. At that time the lake was eutrophic and had a mean TSI of 57. Its aquatic life use was fully supported. The lake was monitored again in 1989. Its TSI was 64, indicating it was eutrophic. It experienced dissolved oxygen problems in September when epilimnetic concentrations dropped below 3.0 mg/l and the hypolimnion had less than 1 mg/l. These low dissolved oxygen values caused the lake to be categorized as not supporting an aquatic life use. The Division has monitored the lake yearly since 1989 in order to document any worsening water quality conditions. In September of 1990 and 1991, similar low dissolved oxygen concentrations developed as in 1989. The lake was therefore categorized as continuing to not support aquatic life. The land use in the lake's watershed is largely agriculture (80%) and this activity is suspected to be the source of nutrients that cause the lake to be eutrophic and not support the aquatic life use.

Other Trends in Water Quality

Lake Acidification. The Division began monitoring three lakes in 1985 on an annual basis to document changes in water quality that could be attributed to acid precipitation. These lakes (Tyner, Bert Combs, and Cannon Creek) were the least buffered of any of the lakes sampled by the Division, which made them candidates for monitoring impacts from acid precipitation. Lakes with an acid neutralizing capacity (ANC) of 41 to 200 uequiv/l (2.5 to 10 mg/l total alkalinity) can be classified as moderately sensitive to acidification. The ANC averages for Tyner, Bert Combs and Cannon Creek lakes were 333, 188 and 160 uequiv/l respectively. These lakes have shown no detectible acidification trends. The monitoring program was discontinued in 1991. A baseline of water quality has been established in these lakes that can be compared to future studies.